Hidden Effects of Extreme Environments on Space Microelectronics (HEESM)

Completed Technology Project (2016 - 2018)

Project Introduction

Study how far-from-equilibrium thermodynamics may help understand continuous entropic production by Total Ionizing Dose (TID) defects that lead to anomalous performance of space microelectronics. This knowledge could provide mitigation of latent damage to cold electronics, providing extended lifetimes in high radiation space environments.

To enhance power systems performance and reliability when operating in extreme environment, we must improve its understanding of materials design principles, the physics and engineering of parts and instrument damage. These new insights have the potential to reveal governing adverse effects for which we must prepare, diagnose, or respond, in critical situations during a mission. They may even illuminate benefits that might provide additional degrees of freedom in designing superior solid state devices for energy transduction when considering operation under extremes both of temperature (hot and cold) and total ionizing dose (TID). We anticipate that bringing this new approach based on non-equilibrium thermodynamics to the community of high-voltage silicon parts specialists and solid-state thermal-to-electric converters will provide unique insights not apparent by any other method that would be eventually applicable to the science exploration of Venus and the outer planets.

Anticipated Benefits

Improved understanding of TID hidden effects could provide mitigation of latent damage to cold electronics, providing extended lifetimes in high radiation environments.

It would provide systems engineers and mission planners of future outer planet science missions with design options to enable extremely cold operations. For example, when exploring ocean worlds around Jupiter and Saturn it could enable extended surface/subsurface operation of probes using electronic circuitry for drilling and grinding operation.

Bringing this new technical approach based on non-equilibrium thermodynamics to the specialist communities of high-voltage silicon parts and solid-state thermal-to-electric converters may provide unique insights not apparent by any other method in designing and optimizing components for operation in extreme space environments.

This technology project would help improve understanding of materials design principles, the physics and engineering of parts and instrument damage under extreme temperature and radiation conditions. It also could help designing superior solid state devices for energy transduction operating under non-linear and non-equilibrium thermodynamic conditions.

JPL_IRAD_Activities Project

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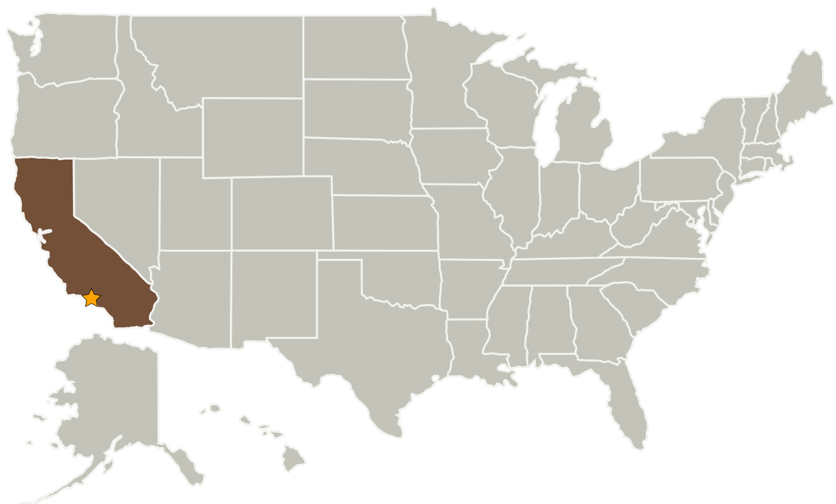
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Jet Propulsion Laboratory(JPL)	Lead Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations
California

Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Jet Propulsion Laboratory (JPL)

Responsible Program:

Center Independent Research & Development: JPL IRAD

Project Management

Program Manager:

Fred Y Hadaegh

Project Manager:

Fred Y Hadaegh

Principal Investigator:

Jean-pierre Fleurial

Co-Investigator:

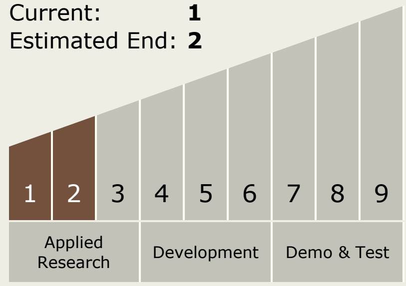
Randall Swimm

Images

JPL_IRAD_Activities Project Image
JPL_IRAD_Activities Project
(https://techport.nasa.gov/image/27797)

Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **2**



Technology Areas

Primary:

- TX02 Flight Computing and Avionics
  - └ TX02.3 Avionics Tools, Models, and Analysis
    - └ TX02.3.2 Space Radiation Analysis and Modeling

Target Destinations

Foundational Knowledge, Others Inside the Solar System

Supported Mission Type

Push